Scientific Inquiry

6-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

6-1.1 Use appropriate tools and instruments (including a spring scale, beam balance, barometer, and sling psychrometer) safely and accurately when conducting a controlled scientific investigation.
Taxonomy Level: 3.2-B Apply Conceptual Knowledge

Previous/future knowledge: In previous grades, students used magnifiers and eyedroppers (K-1.2), rulers (1-1.2), thermometers, rain gauges, balances, and measuring cups (2-1.2), beakers, meter tapes and sticks, forceps/tweezers, tuning forks, graduated cylinders, and graduated syringes (3-1.5), a compass, an anemometer, mirrors, and a prism (4-1.2), and a timing device and a 10x magnifier (5-1.4) safely, accurately, and appropriately. In future grades, students will use these tools when appropriate as well as learn new tools to use when collecting scientific data. A complete list of tools can be found in Appendix A of the Academic Standards.

It is essential for students to know that different instruments or tools are needed to collect different kinds of data.

- A *spring scale* is a tool used to measure the weight of an object or the force on an object.
  - Some spring scales have a slider that moves in response to the weight/force of an object. The measurement is read on one of two scales located on either side of the slider.
  - Some spring scales have a spring that is visible through a clear plastic tube with two scales labeled on either side of the tube.
  - Before an object is attached to the spring scale, make sure the marker is on the zero (0) by adjusting the slider or knob usually found on the top of the scale.
  - A spring scale measures weight or force in newtons (N).
- A *beam balance* (triple) is a tool used to measure the mass of an object.
  - The beam balance contains a pan or platform, three beams with riders/sliders and a pointer.
  - Before measuring, make sure all riders/sliders are set at zero (0), the pointer is in line with its zero (0) mark and the pan is clean.
  - Place an object to be measured on the pan or platform. If the object is placed in a container or on weighing paper, the mass of the container or paper needs to be subtracted from the final mass of the object.
  - Three beams are found on the side opposite of the pan. Each beam is marked in different increments: 100 grams, 10 grams, and tenths (0.1) of a gram up to 10 grams.
  - After placing the object on the pan, the pointer will rise.
  - To determine the mass of the object, gently slide the riders/sliders across the beams until the pointer lines up exactly with the zero (0) mark on the scale. Be sure the riders/sliders with notches are securely placed in their notches.
  - The mass is calculated by adding the sum of the measures indicated by the riders/sliders.
  - Move all riders/sliders back to zero (0) when finished.
  - A beam balance measures the mass of an object in grams (g).

NOTE TO TEACHER: Students do not need to estimate to the hundredths (0.01) of a gram. Measurements estimating to 0.05 of a gram on a triple beam balance will be an expectation in high school Physical Science.

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- A *barometer* is an instrument used to measure air pressure or a change in pressure readings.
  - Many of the barometers have qualitative descriptions of weather conditions associated with air pressure but this alone should not be used to forecast weather.
  - To read your barometer, first tap the glass lightly, but firmly, to ensure that the *reading pointer* attached to the linkage mechanism inside the barometer is not sticking.
  - The other pointer that is found on most instruments is the *set pointer* and is usually made of brass.
  - The set pointer can be turned by means of the knob at the center of the glass so that it covers the reading pointer. If the reading pointer has moved between readings then it can be determined that the pressure is now lower or higher and by how much.
  - A barometer scale is measured in millimeters or inches of mercury or millibars (mb).
- A *sling psychrometer* is a tool used to measure relative humidity.
  - A sling psychrometer is made of two thermometers—a wet bulb and a dry bulb—held together by a handle.
  - The wet bulb thermometer is covered with a piece of cloth and moistened.
  - The two thermometers are then moved through the air. After a period of time the temperature of each thermometer is recorded. A relative humidity chart is used to determine the relative humidity percent.

It is essential for students to use care when handling these tools when conducting an investigation.
- Chemicals should not be placed directly on the beam balance. Place them in a measuring tray or weighing paper.
- Always move the riders of the beam balance to the left after massing an object.
- Care should be taken not to break the barometer and sling psychrometer.

It is also essential for students to use tools from previous grade levels that are appropriate to the content of this grade level such as magnifiers, rulers (measuring to millimeter), rain gauges (measuring in centimeters or inches), thermometers (measuring in ºF and ºC), forceps/tweezers, graduated cylinders (measuring at the meniscus to milliliters), graduated syringes (measuring to milliliters), meter sticks and meter tapes (measuring in meters, centimeters, or millimeters), anemometers (measuring in miles per hour), compasses, 10x magnifiers, or timing devices (measuring in minutes or seconds) to gather data.

NOTE TO TEACHER: See information in previous grades regarding how to use each tool.
All temperature readings during investigations will be taken using the Celsius scale unless the data refers to weather when the Fahrenheit scale is used.

It is not essential for students to use hygrometers, digital balances, ammeters, voltmeters, or mulitmeters. Tools from previous grades that are not appropriate to the content of this grade level are not essential; however, these terms may be used as distracters (incorrect answer options) for assessment, for example eyedroppers, pan balances, measuring cups, beakers, tuning forks, mirrors (plane/flat), or prisms. Students do not need to convert measurements from English to metric or metric to English. Measurements estimating to 0.05 of a gram on a triple beam balance will be an expectation in high school Physical Science.

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Assessment Guidelines:
The objective of this indicator is to *use* tools safely, accurately, and appropriately when gathering data; therefore, the primary focus of assessment should be to apply correct procedures to the use of a spring scale, beam balance, barometer, and sling psychrometer, and other tools essential to the grade level that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* appropriate uses for a spring scale, beam balance, barometer, and sling psychrometer; *illustrate* the appropriate tool for an investigation using pictures, diagrams, or words; *recall* how to accurately determine the measurement from the tool; or *recognize* ways to use science tools safely, accurately, and appropriately.

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6-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

6-1.2 Differentiate between observation and inference during the analysis and interpretation of data.
Taxonomy Level: 4.1-B Analyze Conceptual Knowledge

Previous/Future knowledge: In kindergarten (K-1.3), students predicted and explained information or events based on observation or previous experience. In 3rd grade (3-1.4), students predicted the outcome of a simple investigation and compare the result with the prediction. In 4th grade, students classified observations as either quantitative or qualitative (4-1.1) and distinguished among observations, predictions, and inferences (4-1.4). In 5th grade (5-1.6), students evaluated results of an investigation to formulate a valid conclusion based on evidence and communicated the findings of the evaluation in oral or written form. In 8th grade (8-1.3), students will construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation.

It is essential for students to know that data should be collected throughout a controlled scientific investigation. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
  - Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
  - Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

Data from the investigation should be organized in data tables and represented as diagrams or graphs when appropriate.

A *data table* is used to organize data collected in an experiment so that it can be read easily.

- A data table should be planned before the investigation starts.
- Consider the purpose of the table, the kind and number of items to be included in the table, the number of times a measurement will be made, and the units to be used.
- Data tables are often organized in columns and rows. The columns should have headings that show the quantity and unit of the data in that column.
- The independent (manipulated) variable is listed in the column on the left side. The dependent (responding) variable is listed in the column(s) on the right side.
- If qualitative data is to be gathered, include enough space to write the observations.

Diagrams can be used to identify specific parts or how they work, sequence of events, or how things are alike and different.

Graphs are visuals used to compare data. Graphs show not only information but also relationships between the data. Different types of graphs show different types of information.

- Pictographs use pictures of objects to show quantities.

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- Bar graphs are often used for qualitative observations. The lengths of the bars on a bar graph are used to represent and compare data. A numerical scale is used to determine the lengths of the bars.
- Circle graphs show percentages of a whole. The entire circle is equal to 100% of the data.
- Line graphs are often used when quantitative data is collected over time. Line graphs show how quantitative data changes over time or relationships between manipulated (changing) variable and responding (resulting) variable. The lines on a line graph show the pattern of changes at a glance.

Line graphs are used to represent data that has been collected over a determined amount of time. To construct a line graph, the following steps should be taken:
- Draw a horizontal line (x-axis) and a vertical line (y-axis) that meet at a right angle.
- Identify the independent (manipulated) variable and the dependent (responding) variable from the data.
  - The independent (manipulated) variable is written on the x-axis.
  - The dependent (responding) variable is written on the y-axis.
  - Include appropriate units of measurement for each variable.
- Look at the range of data (lowest and highest) to determine the *intervals* or *increments* (numbers on the axes) of the x-axis and the y-axis.
  - The increments do not need to be the same for both the x-axis and the y-axis, but should be consistent on either axis.
  - Label the point at the right angle as zero (0).
- Plot the data on the graph as matched pairs. For example, every independent (manipulated) variable number will have a corresponding dependent (responding) variable number.
- Connect the points on the line graph.
- Write an appropriate title for the graph that contains the names of both variables.

NOTE TO TEACHER: A mnemonic device that can be used to teach the appropriate locations of the variables on a graph is DRY MIX.
- DRY represents Dependent-Responding-Y-axis.
- MIX represents Manipulated-Independent-X-axis.

In order to be meaningful, the data collected from the investigation should be interpreted and analyzed.
- How the data is analyzed depends on the experiment.
- Sometimes calculations or graphs will be needed to help analyze the data.
- Data will often reveal patterns or trends.
- Patterns often become clear if the data is organized in a data table or graph.

The analyzed data can then be used to draw a valid conclusion about the investigation.
- A *valid conclusion* is a summary of the findings of an experiment based on scientific observations, inferences, and collected data that states the relationship between the independent (manipulated) and dependent (responding) variables.
- When a conclusion statement is made it should state whether the collected data supports the hypothesis or does not support the hypothesis (not that the hypothesis was right or wrong).

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6-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

It is not essential for students to generate new questions from an investigation or construct circle graphs.

Assessment Guidelines:
The objective of this indicator is to *differentiate* between observations and inferences during the analysis and interpretation of data; therefore, the primary focus of assessment should be to distinguish between observations and inferences that can be made from the data collected during an investigation. However, appropriate assessments should also require students to *identify* the appropriate type of graph for the data collected; *compare* observations and inferences; *interpret* data presented on a graph or diagram; *implement* the steps for making a data table or graph;

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6-1.3 Classify organisms, objects, and materials according to their physical characteristics by using a dichotomous key.
Taxonomy Level: 2.3-C Understand Procedural Knowledge

Previous/Future knowledge: In 1st grade (1-1.1), students compared, classified, and sequenced objects by number, shape, texture, size, color, and motion, using Standard English units of measurement where appropriate. In 3rd grade, students classified objects by two of their properties (attributes) (3-1.1) and classified objects or events in sequential order (3-1.2). They will use this skill throughout the remainder of their science instruction.

It is essential for students to know scientists use the skill of classifying to organize objects that are similar in some way into groups to make the relationship among them easier to understand. Objects can be classified based on similar characteristics using a binary classification chart (based on whether or not an object has or does not have a particular property) or an identification key.

A *dichotomous key* is a special identification key that uses a series of paired characteristics that leads to the identification of an organism, object, or material.

- Always begin with a choice from the first pair of characteristics.
- At the end of each characteristic is either the name of the organism, object, or material or directions to go to another step.
- Keep following the choices until the identity is determined.
- Once the identity is determined, the physical characteristics can be identified.

It is not essential for students to construct dichotomous keys.

Assessment Guidelines:
The objective of this indicator is to *classify* organisms, objects, and materials using a dichotomous key; therefore, the primary focus of assessment should be to determine the identity of an organism, object, or material by following a dichotomous key. However, appropriate assessments should also require students to *compare* the properties of organisms, objects, and materials using a dichotomous key; *identify* the name of an organism or object using a dichotomous key; or *recognize* the physical characteristics of an organism or object based on the dichotomous key.

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6-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

6-1.4 Use a technological design process to plan and produce a solution to a problem or a product (including identifying a problem, designing a solution or a product, implementing the design, and evaluating the solution or the product).
Taxonomy Level: 3.2-C Apply Procedural Knowledge

Previous/Future knowledge: In 5th grade (5-1.7), students used a simple technological design process to develop a solution or a product, communicating the design by using descriptions, models, and drawings. In high school Physical Science (PS-1.8), students will compare the processes of scientific investigation and technological design.

It is essential for students to know that science is the process of learning about the natural world by asking questions and trying to find the answers to those questions. Scientific knowledge is used to develop and enhance science knowledge. Technology applies scientific knowledge in order to develop a solution to a problem or create a product to help meet human needs. Technology is usually developed because there is a need or a problem that needs to be solved. Steps in the technological design process include:

- *Identifying a problem or need*
  - Research and gather information on what is already known about the problem or need
- *Designing a solution or a product*
  - Generate ideas on possible solutions or products
  - Evaluate the factors that will limit or restrict the solution or product design
  - Determine the trade-offs of the solutions or products (what must be given up in order to create the solution or product)
- *Implementing the design*
  - Build and test the solution or product
  - Identify any problems with the solution or product
  - If necessary, redesign the solution or product to eliminate any problems in the design
- *Evaluating the solution or the product*
  - Determine if the solution or product solved the problem
  - Identify the pros and cons of the solution or product

The steps of the design can be communicated using descriptions, models, and drawings.

- A *scientific model* is an idea that allows us to create explanations of how the something may work. Models can be physical or mental.

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It is also essential for students to follow appropriate steps when conducting a controlled scientific investigation. In a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent (manipulated) variable
    - Plan for independent (manipulated) and dependent (responding) variables
    - Plan for factors that should be held constant (controlled variables)
    - List the materials needed to conduct the experiment
    - List the procedures to be followed
    - Plan for recording, organizing and analyzing data
- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)
- Compare the results to the hypothesis and write a conclusion that will support or not support the hypothesis based on the recorded data
- Communicate the results to others

It is not essential for students to compare the processes of a controlled scientific investigation and the technological design process or evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).

Assessment Guidelines:

The objective of this indicator is to *use* a technological design process to plan and produce a solution to a problem or a product; therefore, the primary focus of assessment should be to apply the procedures for a technological design process using the steps listed in the indicator. However, appropriate assessments should also require students to *classify* by sequencing the steps of a technological design process or a controlled scientific investigation; *explain* how a particular product or process solves a problem; *summarize* the design process of a solution or product; *summarize* the steps in a controlled scientific investigation; *exemplify* technology; or *identify* the solution or product in a technological design process.

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6-1.5 Use appropriate safety procedures when conducting investigations.
Taxonomy Level: 3.2-C Apply Procedural Knowledge

Previous/Future knowledge: In all grades students use appropriate safety procedures when conducting investigations that are appropriate to their grade, tools, and type of investigations.

It is essential for students to know that care should be taken when conducting a controlled scientific investigation to make sure that everyone stays safe.

Safety procedures to use when conducting science investigations must be:

- Always wear appropriate safety equipment such as goggles or an apron when conducting an investigation.
- Be careful with sharp objects and glass. Only the teacher should clean up broken glass.
- Do not put anything in mouth unless instructed by the teacher.
- Follow all directions for completing the science investigation.
- Follow proper handling of animals and plants in the classroom.
- Keep hands away from eyes when using iron filings.
- Keep the workplace neat. Clean up when done.
- Practice all of the safety procedures associated with the activities or investigations conducted.
- Tell the teacher about accidents or spills right away.
- Use caution when working with heat sources and heated objects.
- Wash hands after each activity.

It is essential for students to use tools safely and accurately, including a spring scale, beam balance, barometer, and sling psychrometer, when conducting investigations.

NOTE TO TEACHER (safety while working with students):

- Teacher materials have lists of "Safety Procedures" appropriate for the suggested activities. Students should be able to describe and practice all of the safety procedures associated with the activities they conduct.
- Most simple investigations will not have any risks, as long as proper safety procedures are followed. Proper planning will help identify any potential risks and therefore eliminate any chance for student injury or harm.
- Teachers should review with students the safety procedures before doing an activity.
- Lab safety rules may be posted in the classroom and/or laboratory where students can view them. Students should be expected to follow these rules.
- A lab safety contract is recommended to notify parents/guardians that classroom science investigations will be hands-on and proper safety procedures will be expected. These contracts should be signed by the student and the parents or guardians and kept on file to protect the student, teacher, school, and school district.
- In the event of a laboratory safety violation or accident, documentation in the form of a written report should be generated. The report should be dated, kept on file, include a signed witness statement (if possible) and be submitted to an administrator.
- Materials Safety Data Sheets (MSDS) must be on file for hazardous chemicals.
- For further training in safety guidelines, you can obtain the SC Lab Safety CD or see the Lab Safety flip-chart (CD with training or flip-chart available from the SC Department of Education).

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It is not essential for students to go beyond safety procedures appropriate to the kinds of investigations that are conducted in a sixth grade classroom.

Assessment Guidelines:
The objective of this indicator is to *use* appropriate safety procedures when conducting investigations**;** therefore, the primary focus of assessment should be to apply correct procedures that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* safety procedures that are needed while conducting an investigation; or *recognize* when safety procedures are being used.